(Partial English Translation)

PCT
INTERNATIONAL SEARCH REPORT

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International Filing Date (Day.Month.Year) 05.10.98
Priority Date (Day.Month.Year) 10.11.97
Applicant (Name) Nissin Unyu Kogyo Co., Ltd.

(Omitted)

Total number of the sheet is three(3).

(Omitted)
4. The title of the invention is approved as submitted by the applicant.
5. The abstract is prepared by International Search Division under the provision 47 of the Law.
6. Figure to be published with the abstract is Fig. 1.

(Omitted, New Abstract)

A. Classification of Invention (International Patent Classification (IPC))
Int.Cl[6] B23H 5/00

B. Fields Searched

Minimum Documentation Searched (International Patent Classification (IPC))
Int.Cl[6] B23H 5/00
B24B 33/02

(Omitted)

C. Documents Considered to Be Relevant

Category *	Citation of Document, with indication, where appropriate, of the relevant passage	Relevant to Claim No.
X A	JP, 62-157722, A (Nissho Astech Kabushiki Kaisha) 13.7.1987 (13.07.87), P3, right-under column, ll.8-20 (No Family)	1-5 6-9
Y A	JP, 4-13520, A (Nissan Jidosha Kabushiki Kaisha) 17.1.1992 (17.01.92), Fig. 1 (No Family)	1-5 6-9
X	JP, 5-38629, A (Nippon Denki Kabushiki Kaisha) 19.2.1993 (19.02.93), P3, column left, ll.1-13 (No Family)	10
X	JP, 59-227324, A (Hitachi Zosen Kabushiki Kaisha) 20.12.1984 (20.12.84), P2, right-under column, ll.1-11 & US, 4625216, A	10

(Omitted)
Date of the Actual Completion of the International Search 16.12.98
Date of Mailing of this International Search Report 06.01.99
Signature of Authorized Office Examiner of Patent Office, Masaaki Sasaki, Tel 03-3581-1101 Ex. 3325

特　許　協　力　条　約

PCT

国際調査報告

（法８条、法施行規則第40、41条）
〔ＰＣＴ１８条、ＰＣＴ規則43、44〕

出願人又は代理人の書類記号　ＮＵ－９８０３－ＰＣＴ	今後の手続きについては、国際調査報告の送付通知様式（ＰＣＴ／ＩＳＡ／２２０）及び下記５を参照すること。	
国際出願番号 ＰＣＴ／ＪＰ９８／０４４９４	国際出願日 （日.月.年）　０５．１０．９８	優先日 （日.月.年）　１０．１１．９７
出願人（氏名又は名称） 日新運輸工業株式会社		

国際調査機関が作成したこの国際調査報告を法施行規則第41条（ＰＣＴ１８条）の規定に従い出願人に送付する。
この写しは国際事務局にも送付される。

この国際調査報告は、全部で　3　ページである。

☐ この調査報告に引用された先行技術文献の写しも添付されている。

１．国際調査報告の基礎

ａ．言語は、下記に示す場合を除くほか、この国際出願がされたものに基づき国際調査を行った。
☐ この国際調査機関に提出された国際出願の翻訳文に基づき国際調査を行った。

ｂ．この国際出願は、ヌクレオチド又はアミノ酸配列を含んでおり、次の配列表に基づき国際調査を行った。
☐ この国際出願に含まれる書面による配列表
☐ この国際出願と共に提出されたフレキシブルディスクによる配列表
☐ 出願後に、この国際調査機関に提出された書面による配列表
☐ 出願後に、この国際調査機関に提出されたフレキシブルディスクによる配列表
☐ 出願後に提出した書面による配列表が出願時における国際出願の開示の範囲を超える事項を含まない旨の陳述書の提出があった。
☐ 書面による配列表に記載した配列とフレキシブルディスクによる配列表に記録した配列が同一である旨の陳述書の提出があった。

２．☐ 請求の範囲の一部の調査ができない（第Ⅰ欄参照）。

３．☐ 発明の単一性が欠如している（第Ⅱ欄参照）。

４．発明の名称は
☒ 出願人が提出したものを承認する。
☐ 次に示すように国際調査機関が作成した。

５．要約は
☐ 出願人が提出したものを承認する。
☒ 第Ⅲ欄に示されているように、法施行規則第47条（ＰＣＴ規則38.2(b)）の規定により国際調査機関が作成した。出願人は、この国際調査報告の発送の日から１カ月以内にこの国際調査機関に意見を提出することができる。

６．要約書とともに公表される図は、
第　1　図とする。☒ 出願人が示したとおりである。　☐ なし
☐ 出願人は図を示さなかった。
☐ 本図は発明の特徴を一層よく表している。

第Ⅲ欄　要約（第１ページの５の続き）

金属管等の長尺な円筒加工物の内面研磨を精度よく加工するための電解複合研磨装置である。円筒加工物Ｗをその円筒部軸心が縦方向に向くように設置する保持装置１３と、縦方向に下向きに支持され上下移動自在とされた外周管３の中に回転自在に支持された回転軸４と、放射方向を向く砥石を備え回転軸４の先端に取り付けられた工具電極５と、外周管３の周囲に巻き付けられ加圧できるようにされたプラスチック管６等を備える。プラスチック管６内部には研磨時には加圧され、外周管３と形材Ｗの円筒部内面の隙間、あるいは外周管３とフリーリング内面との間で膨張し、回転軸４及び工具電極５の高速回転に基づく外周管３のぶれおよび円筒部内における工具電極５のぶれを抑制する。

国際調査報告

国際出願番号　ＰＣＴ／ＪＰ９８／０４４９４

Ａ．　発明の属する分野の分類（国際特許分類（ＩＰＣ））
Ｉｎｔ⁶　Ｃｌ　Ｂ２３Ｈ　５／００

Ｂ．　調査を行った分野

調査を行った最小限資料（国際特許分類（ＩＰＣ））
Ｉｎｔ⁶　Ｃｌ　Ｂ２３Ｈ　５／００
Ｂ２４Ｂ　３３／０２

最小限資料以外の資料で調査を行った分野に含まれるもの
日本国実用新案公報　１９２０－１９９８年
日本国公開実用新案公報　１９７１－１９９８年
日本国登録実用新案公報　１９９４－１９９８年

国際調査で使用した電子データベース（データベースの名称、調査に使用した用語）

Ｃ．　関連すると認められる文献

引用文献のカテゴリー＊	引用文献名　及び一部の箇所が関連するときは、その関連する箇所の表示	関連する請求の範囲の番号
Ｘ Ａ	ＪＰ，６２－１５７７２２，Ａ（日章アステック株式会社）１３．７月．１９８７（１３．０７．８７），Ｐ３右下欄８－２０行（ファミリーなし）	１－５ ６－９
Ｙ Ａ	ＪＰ，４－１３５２０，Ａ（日産自動車株式会社）１７．１月．１９９２（１７．０１．９２），図１（ファミリーなし）	１－５ ６－９
Ｘ	ＪＰ，５－３８６２９，Ａ（日本電気株式会社）１９．２月．１９９３（１９．０２．９３），Ｐ３左欄１－１３行（ファミリーなし）	１０
Ｘ	ＪＰ，５９－２２７３２４，Ａ（日立造船株式会社）２０．１２月．１９８４（２０．１２．８４），Ｐ２右下欄１－１１行&ＵＳ，４６２５２１６，Ａ	１０

☐ Ｃ欄の続きにも文献が列挙されている。　☐ パテントファミリーに関する別紙を参照。

＊　引用文献のカテゴリー
「Ａ」特に関連のある文献ではなく、一般的技術水準を示すもの
「Ｅ」国際出願日前の出願または特許であるが、国際出願日以後に公表されたもの
「Ｌ」優先権主張に疑義を提起する文献又は他の文献の発行日若しくは他の特別な理由を確立するために引用する文献（理由を付す）
「Ｏ」口頭による開示、使用、展示等に言及する文献
「Ｐ」国際出願日前で、かつ優先権の主張の基礎となる出願の日の後に公表された文献
「Ｔ」国際出願日又は優先日後に公表された文献であって出願と矛盾するものではなく、発明の原理又は理論の理解のために引用するもの
「Ｘ」特に関連のある文献であって、当該文献のみで発明の新規性又は進歩性がないと考えられるもの
「Ｙ」特に関連のある文献であって、当該文献と他の１以上の文献との、当業者にとって自明である組合せによって進歩性がないと考えられるもの
「＆」同一パテントファミリー文献

国際調査を完了した日	国際調査報告の発送日
１６．１２．９８	06.01.99

国際調査機関の名称及びあて先	特許庁審査官（権限のある職員）		
日本国特許庁（ＩＳＡ／ＪＰ） 郵便番号１００－８９１５ 東京都千代田区霞が関三丁目４番３号	佐々木　正章	３Ｃ	９１３３
	電話番号　０３－３５８１－１１０１　内線　３３２５		

様式ＰＣＴ／ＩＳＡ／２１０（第２ページ）（１９９８年７月）

特 許 協 力 条 約

EPUS　PCT

国際調査報告

（法８条、法施行規則第40、41条）
〔ＰＣＴ１８条、ＰＣＴ規則43、44〕

出願人又は代理人の書類記号　NU－９８０３－ＰＣＴ	今後の手続きについては、国際調査報告の送付通知様式（ＰＣＴ／ＩＳＡ／２２０）及び下記５を参照すること。	
国際出願番号 ＰＣＴ／ＪＰ９８／０４４９４	国際出願日 (日.月.年)　０５．１０．９８	優先日 (日.月.年)　１０．１１．９７
出願人（氏名又は名称） 日新運輸工業株式会社		

国際調査機関が作成したこの国際調査報告を法施行規則第41条（ＰＣＴ１８条）の規定に従い出願人に送付する。
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この国際調査報告は、全部で　2　ページである。

☐ この調査報告に引用された先行技術文献の写しも添付されている。

１．国際調査報告の基礎

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☐ この国際調査機関に提出された国際出願の翻訳文に基づき国際調査を行った。

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☐ この国際出願に含まれる書面による配列表
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☐ 出願後に提出した書面による配列表が出願時における国際出願の開示の範囲を超える事項を含まない旨の陳述書の提出があった。
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２．☐ 請求の範囲の一部の調査ができない（第Ⅰ欄参照）。

３．☐ 発明の単一性が欠如している（第Ⅱ欄参照）。

４．発明の名称は
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☐ 次に示すように国際調査機関が作成した。

５．要約は
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☐ 本図は発明の特徴を一層よく表している。

国際調査報告

国際出願番号 PCT／JP98／04494

A. 発明の属する分野の分類（国際特許分類（IPC））
Int° Cl B23H 5／00

B. 調査を行った分野

調査を行った最小限資料（国際特許分類（IPC））
Int° Cl B23H 5／00
B24B 33／02

最小限資料以外の資料で調査を行った分野に含まれるもの
日本国実用新案公報 1920－1998年
日本国公開実用新案公報 1971－1998年
日本国登録実用新案公報 1994－1998年

国際調査で使用した電子データベース（データベースの名称、調査に使用した用語）

C. 関連すると認められる文献

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Y A	JP，4－13520，A（日産自動車株式会社）17．1月．1992（17．01．92），図1（ファミリーなし）	1－5 6－9
X	JP，5－38629，A（日本電気株式会社）19．2月．1993（19．02．93），P3左欄1－13行（ファミリーなし）	10
X	JP，59－227324，A（日立造船株式会社）20．12月．1984（20．12．84），P2右下欄1－11行&US，4625216，A	10

☐ C欄の続きにも文献が列挙されている。

☐ パテントファミリーに関する別紙を参照。

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「L」優先権主張に疑義を提起する文献又は他の文献の発行日若しくは他の特別な理由を確立するために引用する文献（理由を付す）
「O」口頭による開示、使用、展示等に言及する文献
「P」国際出願日前で、かつ優先権の主張の基礎となる出願の日の後に公表された文献
「T」国際出願日又は優先日後に公表された文献であって出願と矛盾するものではなく、発明の原理又は理論の理解のために引用するもの
「X」特に関連のある文献であって、当該文献のみで発明の新規性又は進歩性がないと考えられるもの
「Y」特に関連のある文献であって、当該文献と他の1以上の文献との、当業者にとって自明である組合せによって進歩性がないと考えられるもの
「&」同一パテントファミリー文献

国際調査を完了した日
16．12．98

国際調査報告の発送日
06.01.99

国際調査機関の名称及びあて先
日本国特許庁（ISA／JP）
郵便番号100－8915
東京都千代田区霞が関三丁目4番3号

特許庁審査官（権限のある職員）
佐々木 正章
3C 9133

電話番号 03－3581－1101 内線 3325

様式PCT／ISA／210（第2ページ）（1998年7月）

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International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

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A1

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(43) Int. Publication Date: 20 May 1999 (20.05.1999)

(21) Int. Application Number: PCT/JP98/04494

(22) Int. Filing Date: 05 October 1998 (05.10.1998)

(30) Priority Data

9/325215 Filed on 10 November 1997 JP (10.11.1997)

(71) Applicant:

NISSIN UNYU KOGYO CO., LTD. 14-1, Chofuminato-machi, Shimonoseki-shi, Yamaguchi-ken 752-0953 ; (JP). [JP/JP].YPE="E", STATE="US">)

(72) Inventors; and

(75) Inventors/Applicants:

AIURA, Sunao Chofu Seizosho, Kobe Steel, Ltd., 14-1, Chofuminato-machi, Shimonoseki-shi, Yamaguchi-ken 752 0953 ; (JP) [JP/JP]. INOUE, Katsuhiko JP JP JP INOUE, Katsuhiko Chofu Seizosho, Kobe Steel, Ltd., 14-1, Chofuminato-machi, Shimonoseki-shi, Yamaguchi-ken 752-0953 ; (JP) [JP/JP]. SASAKI, Toshihiko JP JP JP SASAKI, Toshihiko Chofu Seizosho, Kobe Steel, Ltd., 14-1, Chofuminato-machi, Shimonoseki-shi, Yamaguchi-ken 752-0953 ; (JP) [JP/JP]. AKAGI, Kazuo JP JP JP AKAGI, Kazuo Nissin Unyu Kogyo Co., Ltd., 14-1, Chofuminato-machi, Shimonoseki-shi, Yamaguchi-ken 752-0953 ; (JP) [JP/JP]. TAKAHASHI, Koji JP JP JP TAKAHASHI, Koji Nissin Unyu Kogyo Co., Ltd., 14-1, Chofuminato-machi, Shimonoseki-shi, Yamaguchi-ken 752-

(81) Designated States:
AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GE, GH, GM, HR, HU, ID, IL, IS, KE, KG, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, US, UZ, VN, YU, ZW ; ARIPO patent (GH, GM, KE, LS, MW, SD, SZ, UG, ZW); Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM); European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE); OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG)

Published

With international search report.

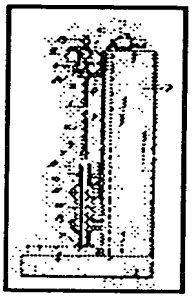
0953 ; (JP) [JP/JP].

(74) Agent:

AKIMOTO, Teruo 1-1, Minami-aoyama 1-chome, Minato-ku, Tokyo 107-0062 ; (JP).

(54) Title: METHOD AND APPARATUS FOR POLISHING INNER SURFACE OF CYLINDRICAL PORTION OF ELONGATED CYLINDRICAL WORK AND ELONGATED CYLINDRICAL WORK

(57) Abstract



An electrolytic abrasive polishing machine for precisely polishing the inner surface of an elongated cylindrical work such as a metal pipe, comprising a holder (13) for disposing a cylindrical work (W) so that the axis of its cylindrical portion faces in the vertical direction, a rotary shaft (4) turnably supported in an outer peripheral pipe (3) so supported as to face downward in the vertical direction and capable of moving up and down, a tool electrode (5) equipped with a grinding wheel facing in a radial direction and fitted to the distal end of the rotary shaft (4) and a plastic pipe (6) wound around the periphery of the outer peripheral pipe (3) and capable of pressurizing. The inside of the plastic pipe (6) is pressurized at the time of polishing, expands in a gap between the outer peripheral pipe (3) and the inner surface of the cylindrical portion of the work (W) or between the outer peripheral pipe (3) and the inner surface of a free ring and suppresses the deflection of the outer peripheral pipe (3) and the deflection of the tool electrode (5) inside the cylindrical portion that would be caused by the high speed revolutions of the rotary shaft (4) and the tool electrode (5).

PATENT COOPERATION TREATY

From the INTERNATIONAL BUREAU

PCT

NOTIFICATION OF RECEIPT OF RECORD COPY

(PCT Rule 24.2(a))

To:

AKIMOTO, Teruo
1-1, Minami-aoyama 1-chome
Minato-ku
Tokyo 107-0062
JAPON

Date of mailing (day/month/year)	**IMPORTANT NOTIFICATION**
19 October 1998 (19.10.98)	
Applicant's or agent's file reference	**International application No.**
NU-9803-PCT	PCT/JP98/04494

The applicant is hereby notified that the International Bureau has received the record copy of the international application as detailed below.

Name(s) of the applicant(s) and State(s) for which they are applicants:

NISSIN UNYU KOGYO CO., LTD. (for all designated States except US)
AIURA, Sunao et al (for US)

International filing date	:	05 October 1998 (05.10.98)
Priority date(s) claimed	:	10 November 1997 (10.11.97)
Date of receipt of the record copy by the International Bureau	:	16 October 1998 (16.10.98)
List of designated Offices	:	

AP :GH,GM,KE,LS,MW,SD,SZ,UG,ZW
EA :AM,AZ,BY,KG,KZ,MD,RU,TJ,TM
EP :AT,BE,CH,CY,DE,DK,ES,FI,FR,GB,GR,IE,IT,LU,MC,NL,PT,SE
OA :BF,BJ,CF,CG,CI,CM,GA,GN,GW,ML,MR,NE,SN,TD,TG
National :AL,AM,AT,AU,AZ,BA,BB,BG,BR,BY,CA,CH,CN,CU,CZ,DE,DK,EE,ES,FI,GB,GE,GH,GM,HR,HU,ID,IL,IS,KE,KG,KR,KZ,LC,LK,LR,LS,LT,LU,LV,MD,MG,MK,MN,MW,MX,NO,NZ,PL,PT,RO,RU,SD,SE,SG,SI,SK,SL,TJ,TM,TR,TT,UA,UG,US,UZ,VN,YU,ZW

ATTENTION

The applicant should carefully check the data appearing in this Notification. In case of any discrepancy between these data and the indications in the international application, the applicant should immediately inform the International Bureau.

In addition, the applicant's attention is drawn to the information contained in the Annex, relating to:

- [X] time limits for entry into the national phase
- [X] confirmation of precautionary designations
- [X] requirements regarding priority documents

A copy of this Notification is being sent to the receiving Office and to the International Searching Authority.

The International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20, Switzerland

Facsimile No. (41-22) 740.14.35

Authorized officer:

M. Sakai

Telephone No. (41-22) 338.83.38

INFORMATION ON TIME LIMITS FOR ENTERING THE NATIONAL PHASE

The applicant is reminded that the "national phase" must be entered before each of the designated Offices indicated in the Notification of Receipt of Record Copy (Form PCT/IB/301) by paying national fees and furnishing translations, as prescribed by the applicable national laws.

The time limit for performing these procedural acts is **20 MONTHS** from the priority date or, for those designated States which the applicant elects in a demand for international preliminary examination or in a later election, **30 MONTHS** from the priority date, provided that the election is made before the expiration of 19 months from the priority date. Some designated (or elected) Offices have fixed time limits which expire even later than 20 or 30 months from the priority date. In other Offices an extension of time or grace period, in some cases upon payment of an additional fee, is available.

In addition to these procedural acts, the applicant may also have to comply with other special requirements applicable in certain Offices. **It is the applicant's responsibility** to ensure that the necessary steps to enter the national phase are taken in a timely fashion. Most designated Offices do not issue reminders to applicants in connection with the entry into the national phase.

For detailed information about the procedural acts to be performed to enter the national phase before each designated Office, the applicable time limits and possible extensions of time or grace periods, and any other requirements, see the relevant Chapters of Volume II of the PCT Applicant's Guide. Information about the requirements for filing a demand for international preliminary examination is set out in Chapter IX of Volume I of the PCT Applicant's Guide.

GR and ES became bound by PCT Chapter II on 7 September 1996 and 6 September 1997, respectively, and may, therefore, be elected in a demand or a later election filed on or after 7 September 1996 and 6 September 1997, respectively, regardless of the filing date of the international application. (See second paragraph above.)

Note that only an applicant who is a national or resident of a PCT Contracting State which is bound by Chapter II has the right to file a demand for international preliminary examination.

CONFIRMATION OF PRECAUTIONARY DESIGNATIONS

This notification lists only specific designations made under Rule 4.9(a) in the request. It is important to check that these designations are correct. Errors in designations can be corrected where precautionary designations have been made under Rule 4.9(b). The applicant is hereby reminded that any precautionary designations may be confirmed according to Rule 4.9(c) before the expiration of 15 months from the priority date. If it is not confirmed, it will automatically be regarded as withdrawn by the applicant. There will be no reminder and no invitation. Confirmation of a designation consists of the filing of a notice specifying the designated State concerned (with an indication of the kind of protection or treatment desired) and the payment of the designation and confirmation fees. Confirmation must reach the receiving Office within the 15-month time limit.

REQUIREMENTS REGARDING PRIORITY DOCUMENTS

For applicants who have not yet complied with the requirements regarding priority documents, the following is recalled.

Where the priority of an earlier national, regional or international application is claimed, the applicant must submit a copy of the said earlier application, certified by the authority with which it was filed ("the priority document") to the receiving Office (which will transmit it to the International Bureau) or directly to the International Bureau, before the expiration of 16 months from the priority date, provided that any such priority document may still be submitted to the International Bureau before that date of international publication of the international application, in which case that document will be considered to have been received by the International Bureau on the last day of the 16-month time limit (Rule 17.1(a)).

Where the priority document is issued by the receiving Office, the applicant may, instead of submitting the priority document, request the receiving Office to prepare and transmit the priority document to the International Bureau. Such request must be made before the expiration of the 16-month time limit and may be subjected by the receiving Office to the payment of a fee (Rule 17.1(b)).

If the priority document concerned is not submitted to the International Bureau or if the request to the receiving Office to prepare and transmit the priority document has not been made (and the corresponding fee, if any, paid) within the applicable time limit indicated under the preceding paragraphs, any designated State may disregard the priority claim, provided that no designated Office may disregard the priority claim concerned before giving the applicant an opportunity to furnish the priority document within a time limit which is reasonable under the circumstances.

Where several priorities are claimed, the priority date to be considered for the purposes of computing the 16-month time limit is the filing date of the earliest application whose priority is claimed.

PATENT COOPERATION TREATY

From the INTERNATIONAL BUREAU

PCT

NOTIFICATION CONCERNING SUBMISSION OR TRANSMITTAL OF PRIORITY DOCUMENT

(PCT Administrative Instructions, Section 411)

To:

AKIMOTO, Teruo
1-1, Minami-aoyama 1-chome
Minato-ku
Tokyo 107-0062
JAPON

Date of mailing (day/month/year) 01 February 1999 (01.02.99)	
Applicant's or agent's file reference NU-9803-PCT	**IMPORTANT NOTIFICATION**
International application No. PCT/JP98/04494	International filing date (day/month/year) 05 October 1998 (05.10.98)
International publication date (day/month/year) Not yet published	Priority date (day/month/year) 10 November 1997 (10.11.97)
Applicant NISSIN UNYU KOGYO CO., LTD. et al	

1. The applicant is hereby notified of the date of receipt (except where the letters "NR" appear in the right-hand column) by the International Bureau of the priority document(s) relating to the earlier application(s) indicated below. Unless otherwise indicated by an asterisk appearing next to a date of receipt, or by the letters "NR", in the right-hand column, the priority document concerned was submitted or transmitted to the International Bureau in compliance with Rule 17.1(a) or (b).

2. This updates and replaces any previously issued notification concerning submission or transmittal of priority documents.

3. An **asterisk(*)** appearing next to a date of receipt, in the right-hand column, denotes a priority document submitted or transmitted to the International Bureau but not in compliance with Rule 17.1(a) or (b). In such a case, **the attention of the applicant is directed** to Rule 17.1(c) which provides that no designated Office may disregard the priority claim concerned before giving the applicant an opportunity, upon entry into the national phase, to furnish the priority document within a time limit which is reasonable under the circumstances.

4. The **letters "NR"** appearing in the right-hand column denote a priority document which was not received by the International Bureau or which the applicant did not request the receiving Office to prepare and transmit to the International Bureau, as provided by Rule 17.1(a) or (b), respectively. In such a case, **the attention of the applicant is directed** to Rule 17.1(c) which provides that no designated Office may disregard the priority claim concerned before giving the applicant an opportunity, upon entry into the national phase, to furnish the priority document within a time limit which is reasonable under the circumstances.

Priority date	Priority application No.	Country or regional Office or PCT receiving Office	Date of receipt of priority document
10 Nove 1997 (10.11.97)	9/325215	JP	22 Janu 1999 (22.01.99)

The International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20, Switzerland

Facsimile No. (41-22) 740.14.35

Authorized officer

R. Forax RF

Telephone No. (41-22) 338.83.38

WO 99/24206
PCT/JP98/04494

PATENT COOPERATION TREATY

From the INTERNATIONAL BUREAU

PCT

NOTICE INFORMING THE APPLICANT OF THE COMMUNICATION OF THE INTERNATIONAL APPLICATION TO THE DESIGNATED OFFICES

(PCT Rule 47.1(c), first sentence)

To:
AKIMOTO, Teruo
1-1, Minami-aoyama 1-chome
Minato-ku
Tokyo 107-0062
JAPON

Date of mailing (day/month/year)	
20 May 1999 (20.05.99)	
Applicant's or agent's file reference NU-9803-PCT	**IMPORTANT NOTICE**
International application No. PCT/JP98/04494	**International filing date** (day/month/year) 05 October 1998 (05.10.98)
Priority date (day/month/year) 10 November 1997 (10.11.97)	
Applicant NISSIN UNYU KOGYO CO., LTD. et al	

1. Notice is hereby given that the International Bureau has communicated, as provided in Article 20, the international application to the following designated Offices on the date indicated above as the date of mailing of this Notice:
   AU,CN,EP,IL,KR,US

   In accordance with Rule 47.1(c), third sentence, those Offices will accept the present Notice as conclusive evidence that the communication of the international application has duly taken place on the date of mailing indicated above and no copy of the international application is required to be furnished by the applicant to the designated Office(s).

2. The following designated Offices have waived the requirement for such a communication at this time:
   AL,AM,AP,AT,AZ,BA,BB,BG,BR,BY,CA,CH,CU,CZ,DE,DK,EA,EE,ES,FI,GB,GE,GH,GM,HR,HU,ID,IS,KE,KG,KZ,LC,LK,LR,LS,LT,LU,LV,MD,MG,MK,MN,MW,MX,NO,NZ,OA,PL,PT,RO,RU,SD,SE,SG,SI,SK,SL,TJ,TM,TR,TT,UA,UG,UZ,VN,YU,ZW
   The communication will be made to those Offices only upon their request. Furthermore, those Offices do not require the applicant to furnish a copy of the international application (Rule 49.1(a-bis)).

3. Enclosed with this Notice is a copy of the international application as published by the International Bureau on
   20 May 1999 (20.05.99) under No. WO 99/24206

REMINDER REGARDING CHAPTER II (Article 31(2)(a) and Rule 54.2)

If the applicant wishes to postpone entry into the national phase until 30 months (or later in some Offices) from the priority date, **a demand for international preliminary examination** must be filed with the competent International Preliminary Examining Authority before the expiration of 19 months from the priority date.

It is the applicant's sole responsibility to monitor the 19-month time limit.

Note that only an applicant who is a national or resident of a PCT Contracting State which is bound by Chapter II has the right to file a demand for international preliminary examination.

REMINDER REGARDING ENTRY INTO THE NATIONAL PHASE (Article 22 or 39(1))

If the applicant wishes to proceed with the international application in the **national phase**, he must, within 20 months or 30 months, or later in some Offices, perform the acts referred to therein before each designated or elected Office.

For further important information on the time limits and acts to be performed for entering the national phase, see the Annex to Form PCT/IB/301 (Notification of Receipt of Record Copy) and Volume II of the PCT Applicant's Guide.

The International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20, Switzerland

Facsimile No. (41-22) 740.14.35

Authorized officer
J. Zahra

Telephone No. (41-22) 338.83.38

VERIFICATION OF TRANSLATION

I, the below named translator, hereby declare that:
I am knowledgeable in the English language and in the language in which the below identified international application was filed in Japan under PCT in the receiving office of the Japanese Patent Office on October 5, 1998 under number PCT/JP98/04494 with claiming the priority of Japanese Patent Application No.9-325215 filed on November 10, 1997, and that I believe the English translation of the international application No.PCT/JP98/04494 is a true and complete translation of the above identified international application as filed.

Date : July 1, 1999
Name of the translator : MASAKI TANJI

Signature of the translator Masaki Tanji
Post Office Address :c/o Akimoto & Co., New Aoyama Building (West), 1-1-1, Minami-aoyama, Minato-ku, Tokyo, 107 Japan

PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re application	:	Sunao Aiura, et al.
Filed	:	Herewith
For	:	METHOD AND APPARATUS FOR POLISHING INTERNAL SURFACE OF LONG SIZED CYLINDRICAL WORKPIECES AND LONG SIZED CYLINDRICAL WORKPIECES
Attorney's Docket	:	AK-284XX

* *

Express Mail Mailing Number EL231114516US
Date of Deposit - July 8, 1999

I hereby certify that the following items are being deposited with the United States Postal Service "Express Mail Post Office to Addressee" service under 37 CFR 1.10 on the date indicated above and as addressed to BOX PCT, Assistant Commissioner for Patents, Washington, D.C. 20231:

U.S. PCT Application of Sunao Aiura; Katsuhiko Inoue; Toshihiko Sasaki; Kazuo Akagi; Koji Takahashi entitled METHOD AND APPARATUS FOR POLISHING INTERNAL SURFACE OF LONG SIZED CYLINDRICAL WORKPIECES AND LONG SIZED CYLINDRICAL WORKPIECES consisting of

PTO Form 1390, in triplicate;

A check in the amount of $918.00 to cover the application filing fee;

Notification of Receipt of Record Copy, Form PCT/IB/301;

Notification Concerning Submission of Priority Documents, Form PCT/IB/304;

Notice Informing the Applicant of the Communication of the International Application to the Designated Offices, Form PCT/IB/308;

Express Mail Label Number: EL231114516US
Attorney's Docket: AK-284XX

International Application published under the Patent Cooperative Treaty (PCT of Application No. WO 99/24206) comprising cover page and the Abstract;

Verification of Translation, together with copy of the application comprising 21 pages of specification, 4 pages of claims, 1 page of abstract and 4 sheets of drawings;

Application comprising 21 pages of specification; 4 pages of claims, 1 page of Abstract, 4 sheets of formal drawings of Figs 1 to 5, and an unsigned Declaration and Power of Attorney;

a Preliminary Amendment;

Information Disclosure Statement, Form 1449, International Search Report Form PCT/ISA/210, a partial translation of the search report and 4 references.

The above items are deposited with signatures and dated by the filing attorney as appropriate.

Michael Cheek

rev. 3/97

* *

(Express Mail Transmittal Letter Continued Next Page)

Express Mail Label Number: EL231114516US
Attorney's Docket: AK-284XX

PLACE OF DEPOSIT _____

TIME OF LAST SCHEDULED PICK-UP FOR THAT PLACE AND DATE OF DEPOSIT _____

DATE OF DEPOSIT _____

TIME OF DEPOSIT _____

DATE OF ENTRY _____

TIME OF ENTRY _____

DEPOSITOR'S INITIALS _____

CLG:jow/207724

SPECIFICATION

METHOD AND APPARATUS FOR POLISHING INTERNAL SURFACE OF LONG SIZED CYLINDRICAL WORKPIECES AND LONG SIZED CYLINDRICAL WORKPIECES

Field of the Invention

The present invention relates to a polishing method and apparatus for mirror processing of the internal surface of a long sized cylindrical workpiece such as a metallic tube, shape or the like with a cylindrical portion using electrolytic integrated polishing technology, and to a long sized cylindrical workpiece polished by electrolytic integrated polishing according to the method.

Background Art

Cylindrical portions of fluid pressure cylinders such as hydraulic cylinders, air cylinders or the like are required to have roundness of 25μm for hydraulic cylinders and 150μm for air cylinders. For example, because aluminum extrusion hollow shapes used for these cylinders have inadequate precision by normal extrusion only, roundness or dimensional precision of cylindrical portions of most products thereof are improved by machining such as cutting or by post-machining burnishing. However, a material, the cylindrical portion of which has a small bore or a longitudinal size larger than the bore, can not be machined. Therefore, the current situation has been such that, for example, yield is declining for not achieving required

roundness, or productivity is staying low for having to machine the pieces, one by one, of a long sized material which must be cut into product length beforehand.

On the other hand, electrolytic integrated polishing technology, a hybrid of elution by electrolyte and abrasion by abrasives, is known as a method for polishing the surface of metal with a high precision. The electrolytic integrated polishing technology, applied to mirror finishing of the internal surface of metallic tubes, generally inserts a rotation axis, to the tip of which a tool electrode is attached, into a metallic tube, rotates the metallic tube about the rotation axis, then supplies electrolyte inside the metallic tube and passes current, and polishes the internal surface of the metallic tube by a grindstone attached to the tool electrode, withdrawing the rotation axis slowly.

With such electrolytic integrated polishing methods for the internal surface of metallic tubes, abrasion of the grindstone prevents high precision mirror finishing due to inappropriate polishing of the internal surface. Therefore, apparatuses coping with abrasion of the grindstone by applying pressing force onto the grindstone via a leaf, a diaphragm or the like are conventionally known. (See Japanese Utility Model Laid-Open Publication No. Hei 4-130120, 5-86429 and so on.)

The above mentioned conventional method using a leaf can not preserve the desired polishing performance because pressing force decreases as the grindstone abrades, especially in narrow places such as the internal surface of a long sized metallic tube. Besides, there have been shortcomings such as the necessity of a specific insertion guide for inserting the polishing tool into the metallic tube because the leaf generates force by being bent to a predetermined extent.

On the other hand, although a method using a diaphragm can resolve the above mentioned problem caused by the leaf, a plurality of diaphragms corresponding to a plurality of grindstones must be individually disposed, which makes processing of the installation sections, and installation work complicated. Besides pressing force applied to individual grindstones is not uniform due to variation occurred in the plurality of diaphragms, which makes mirror finishing with a high precision impossible.

The above mentioned method is mainly applied to processing of the internal surface of pipes made from steel or stainless steel. Most apparatuses are horizontal types that can easily perform processing of long sized products, while there are few vertical types. (See Japanese Patent Laid-Open Publication No. Hei 3-98758.) Furthermore, there is no concrete example of application to aluminum extrusion shapes having a variety of external shapes.

Machining (cutting, for example) of the internal surface of the cylindrical portion of an aluminum extrusion hollow shape is more difficult than processing of external surface. Besides, long materials, with difficulties in processing due to problems with rigidity of the tool, must be cut short for processing in order to preserve a certain processing precision. Therefore, other than increase in cost, ultra high precision mirror finishing of aluminum alloy by cutting has been difficult because aluminum alloy, having a low rigidity which is about one-third of steel and a coefficient of thermal expansion twice as large as steel, is easy to be deformed by cutting resistance or cutting heat.

On the other hand, electrolytic integrated polishing which is an ultra high precision finishing technology with a roundness of finished surface equal to or smaller than 10μm and a surface roughness equal to or smaller than 1μm, can be applied to long sized pipes. However, a problem remains in that directly applying electrolytic integrated polishing methods and apparatuses that have been mainly used for polishing of the internal surface of steel or stainless steel tubes to polishing of the internal surface of a cylindrical portion of an aluminum extrusion hollow shape will not result in processing with a high precision.

For example, the inventors of the present invention failed to obtain the desired processing precision by electrolytic

integrated polishing of the internal surface of an aluminum extrusion tube using a conventional electrolytic integrated polishing apparatus (a type in which axial directions of a long sized metallic tube and a tool electrode are horizontally oriented, and the metallic tube and the tool electrode are rotated in opposite directions with each other.) This is because processing needed be performed with the pressing force of the grindstone controlled at a low pressure due to softness and easiness to deformation of aluminum, having a low strength and a low rigidity which are about one-third of steel or stainless steel, and because precision of processing degrades by deflection of the axial center due to influence of weight of the tool electrode supported horizontally by the rotation axis.

Besides, since rotating metallic shapes having a variety of external shapes is virtually impossible, long sized cylindrical workpieces to which the above mentioned electrolytic integrated polishing apparatus can be applied are limited to cylinder pipes.

It is an object of the present invention, having been made considering the above mentioned problems with prior arts, to provide an electrolytic integrated polishing method and apparatus which enables high precision polishing of the internal surfaces of the cylindrical portions of metallic shapes having a variety of external shapes such as aluminum extrusion hollow shapes or the like, and to provide long sized cylindrical

workpieces having internal surfaces of the cylindrical portions polished with a high precision.

Disclosure of the Invention

The method according to the present invention is an electrolytic integrated polishing method for polishing the internal surface of the cylindrical portion of a long sized cylindrical workpiece by integrating elution by electrolyte and abrasion by a grindstone attached to a tool electrode inserted into the cylindrical portion, characterized by disposing the long sized cylindrical workpiece so that the axial center of its cylindrical portion is aligned with the vertical direction, inserting the tool electrode attached to the tip of a rotation axis supported downward similarly along the vertical direction into the cylindrical portion, and rotating as well as relatively moving the tool electrode vertically.

Besides, the apparatus according to the present invention is an electrolytic integrated polishing apparatus for polishing the internal surface of the cylindrical portion of a long sized cylindrical workpiece by integrating elution by electrolyte and abrasion by a grindstone attached to a tool electrode inserted into the cylindrical portion, characterized by comprising a work supporting unit for disposing the long sized cylindrical workpiece so that the axial center of its cylindrical portion is aligned with the vertical direction, a rotation axis

supported downward along the vertical direction and inserted into the cylindrical portion of the above mentioned long sized cylindrical workpiece, the tool electrode attached to the tip of the rotation axis, and a transportation unit for moving the above mentioned rotation axis and/or the work supporting unit along the axial direction.

In the present method and apparatus, because the rotation axis is supported downward along the vertical direction and the tool electrode is attached to the tip thereof, influence of the weight of the tool electrode and the rotation axis themselves is eliminated to suppress deflection of the tool electrode, which improves the precision of processing. Besides, the present method and apparatus can be similarly applied to a variety of metallic shapes such as aluminum extrusion hollow shape or the like having a variety of external shapes, because only the tool electrode is rotated without rotating the long sized cylindrical workpiece.

Here, the above mentioned transportation unit may be disposed at either one or both sides of the rotation axis and the work supporting unit. That is, any disposition will do if the long sized cylindrical workpiece and the tool electrode move along the axial direction relatively to each other.

Note that as an embodiment of the above mentioned

polishing apparatus, the above mentioned rotation axis is free-rotatably supported inside an external tube supported downward along the vertical direction. The external tube does not rotate, preferably covers almost throughout the whole length of the rotation axis except for the tool electrode at the tip thereof, and is moved along the axial direction simultaneously with the rotation axis. In this case, since the rotation axis is free-rotatably supported at the center of the external tube, deflection of the tool electrode when rapidly rotating is suppressed to improve the precision of processing.

Besides, when the above external tube is provided, it is preferable to wind a plastic tube spirally around the peripheral thereof and to enable pressurization inside the plastic tube. When the external tube is inserted, for example, into the cylindrical portion of a long sized cylindrical workpiece and pressure is applied onto the plastic tube at the state, the plastic tube expands and is pressed against the internal surface of the cylindrical portion. The effect, preventing minute deflections caused by rotation of the rotation axis and the tool electrode and maintaining the external tube always at the center of the cylindrical portion, results in further improvement of the precision of processing.

Furthermore, preferably a hollow portion is provided inside the tool electrode, a pressure tube composed of silicon

tube or the like, inside of which can be pressurized, is provided in the above mentioned hollow portion. By pressurizing inside the pressure tube, elastic grindstones can be pressed with a constant pressure toward radial directions. Besides, a constant pressing force is always maintained when the grindstones are worn out.

Moreover, by the electrolytic integrated polishing method and apparatus, it becomes possible to perform finish polishing, without machining, of a long sized metallic shape, the length of the cylindrical portion of which is ten times as large as the diameter, or more, with a roundness of the internal surface of the cylindrical portion equal to or smaller than 10μm and a surface roughness Rmax along the axial and circular directions equal to or smaller than 1μm.

Other characteristics of the present invention will be described in detail in the following sections about preferred embodiments of the invention.

Brief Description of the Drawings

Fig.1 is a general view of an electrolytic integrated polishing apparatus according to the present invention. Fig.2 is a view illustrating the major portion thereof. Fig.3 is a vertical cross sectional view of the tool electrode. Fig.4 is a horizontal cross sectional view of the electrode. Fig.5 is a

cross sectional view of an aluminum extrusion hollow shape used in the example.

Best Mode for Carrying out the Invention

The electrolytic integrated polishing apparatus according to the present invention will be described in detail hereinafter with reference to Figs. 1 to 5.

As shown in Figs.1 and 2, the electrolytic integrated polishing apparatus includes a platform 1, a frame 2 disposed on the platform, an external tube 3 vertically disposed, a rotation axis 4 vertically and free-rotatably disposed via a plurality of bearings (not shown) inside the external tube 3, a tool electrode 5 attached to the tip of the rotation axis 4 at the lower portion of the external tube 3, a plastic tube 6, inside of which can be pressurized by a mechanism (not shown), comprising a silicon tube or the like and being spirally wound around the peripheral of the external tube 3, a guide 7 attached to the frame 2, a sliding member 8 freely and vertically slidable along the guide 7, a supporting member 9 fixed to the sliding member 8 for supporting the upper end of the external tube 3, a bearing member 10 fixed to the sliding member 8 for supporting nearby the upper portion of the rotation axis 4, a transportation motor 11 for sliding the sliding member 8 vertically along the guide 7 thus moving the external tube 3 and the rotation axis 4 upward and downward, a motor 12 attached to the sliding member 8 for rotating the rotation axis 4, and a fixed chuck 13 (positive pole energizing chuck) for fixing a

long sized cylindrical workpiece W.

In the electrolytic integrated polishing apparatus, the rotation axis 4 is a hollow shaft (see Fig.3) the top of which enabling introduction of air into a hollow bore 4a via a rotary joint 15. Besides, the present apparatus also includes a free ring mechanism 16, which is located above the fixed chuck 13, freely slidable along the guide 7 and can be fixed to any appropriate position, a restricting sleeve 17 disposed on the free ring mechanism 16, a liquid receiver 18 for receiving electrolyte flowing out from an opening of the restricting sleeve 17, a free ring mechanism 19 fixed at a lower position of the fixed chuck 13, and a negative pole energizing brush 20 contacting the rotation axis 4.

The free ring mechanisms 16 and 19 have approximately the same structure, wherein free rings 23, 24, 25 and 26 are free-rotatably supported, in two layers within fixed sleeves 21 and 22, independent of each other, via a mechanical seal. Then, the free ring mechanisms 16 and 19 are kept in contact, via seal packings 27 and 28 with the upper and the lower openings of the cylindrical portion of the long sized cylindrical workpiece W attached to the fixed chuck 13. The free rings 23 to 26 have the same or slightly larger bore than the finished bore of the cylindrical portion of the long sized cylindrical workpiece W, and approximately the same length as that of an elastic grindstone,

described hereafter, of the tool electrode 5. The free rings 23 to 26 are rotated freely and synchronously by the pressing force of the elastic grindstone, and prevent the end surface of the cylindrical portion of the long sized cylindrical workpiece W from deforming into a bell-mouth shape because of the polishing.

Besides, the restricting sleeve 17, successively disposed on the free ring mechanism 16, has approximately the same bore as those of the free rings 23 and 24.

As shown in Fig.3, the rotation axis 4 is free-rotatably supported in the external tube 3 by the bearing 30. Besides, a felt-like seal 33 intermediates between a seal holder 31 screwed into the lower end of the external tube 4 and a seal holder 32 fixed to the rotation axis 4 to prevent electrolyte from flowing in between the external tube 3 and the rotation axis 4 which are rotating relatively to each other.

The tool electrode 5 is attached, via a mounting member 34, to the tip of the rotation axis 4 projecting from the lower end of the external tube 3. As also shown in Fig.4, hollow electrodes 35 and 36 are attached to the upper and the lower sections of the tool electrode 5, apart from each other by a predetermined interval. Openings are provided to each of the electrodes 35 and 36, in a radial manner, 180 degrees apart from each other. The openings of each of the electrodes 35 and 36 are faced to directions 90 degrees apart. In each opening, as

abrasives, elastic grindstones 37 and 38 for coarse polishing and finishing, respectively, are supported as well as a holder 39 along radial directions to be freely slidable. Disposed in the hollow of the tool electrode 5 is a pressure tube 41, composed of a silicon tube or the like, one end of which communicates with the hollow bore 4a of the rotation axis 4 while the other end thereof is sealed by a plug 40. The pressure tube 41 expands by air introduced into the hollow bore 4a via the rotary joint 15, and presses the elastic grindstones 37 and 38, toward radial directions, against the internal surface of the cylindrical portion of the long sized cylindrical workpiece W with a constant pressure according to the air pressure. A hard glass 42 is attached to the side walls of the openings of the electrodes 35 and 36 to reduce the friction between the electrodes and the holder 39.

In order to prevent leakage current, insulation is provided between the supporting member 9 and the external tube 3 and between the bearing member 10 and the rotation axis 4, and the external surface of the external tube 4 is insulated by sheathing. Besides, the metallic portions of the tool electrode 5 are insulated by sheathing except that the sides of the external surface of the electrode 35 sandwiching the elastic grindstone 37 are exposed. As for the exposed surface, the front side of the direction of rotation of the elastic grindstone 37 is an exposed surface 35a for passivation coating generation, and the

rear side thereof is an exposed surface 35b for intensive elution.

The plastic tube 6 wound around the external tube 3 is, as shown in Fig.2, located between the external surface of the external tube 3 and the internal surface of the cylindrical portion of the long sized cylindrical workpiece W, the free rings 23 and 24, and the restricting sleeve 17, respectively. Applying pressure inside of the plastic tube 6 expands and presses the plastic tube 6 against the internal surface of the above mentioned elements, which prevents minute deflections of the external tube 3 caused by rapid rotation of the rotation axis 4 and the tool electrode 5.

The polishing process using the electrolytic integrated polishing apparatus will be described next.

Firstly, the long sized cylindrical workpiece W to be processed is grasped by the fixed chuck 13 and fixed on the free ring mechanism 19 via the seal packing 28, and the free ring mechanism 16 is fixed on the long sized cylindrical workpiece W via the seal packing 27. Here, the axial center of the internal surfaces of the cylindrical portion of the long sized cylindrical workpiece W, each of the free rings 23 to 26 and the restricting sleeve 17 must be aligned on the same axial line, and, at the same time, they must be aligned on the same axial line of the external tube 3, the rotation axis 4 and the tool electrode 5. (see Fig. 1)

Under this situation the transportation motor 11 is driven to bring down the sliding member 8 and to insert the tool electrode 5 from the restricting sleeve 17. Thus the bringing down is stopped at a position shown in Fig.2, that is, a position where the elastic grindstone 37 for coarse polishing meets the lower position, for example, being the location of the free ring mechanism 19, of the cylindrical portion of the long sized cylindrical workpiece W. Because no air is introduced into the pressure tube 41 and the inside of the plastic tube 6 is not pressurized, the tool electrode 5 and the external tube 3 can be smoothly inserted without resistance.

Next, air is introduced into the plastic tube 6 and the pressure tube 41 for pressurization, and electrolyte is introduced from the electrolyte injection opening at the lower portion of the free ring mechanism 19. Then the motor 12 is driven to rapidly rotate the rotation axis 4 and the tool electrode 5. The rotation axis 4 and the fixed chuck 13 are energized, setting the electrodes 35 and 36 to be the negative pole and the long sized cylindrical workpiece W to be the positive pole and driving the transportation motor 11 to bring up the tool electrode 5 at a constant velocity.

Now, the electrolyte rises through the gap between the tool electrode 5 and the internal surfaces of the free rings 25 and 26, and passes through the gap between the internal surface

of the cylindrical portion of the long sized cylindrical workpiece W and the external surface of the external tube 3, the gap between the internal surfaces of the free rings 24 and 23 and the external surface of the external tube 3, and the gap between the internal surface of the restricting sleeve 17 and the external surface of the external tube 3. Then the electrolyte is discharged to the liquid receiver 18, recovered and, after having the polishing sludge separated by precipitation and filtered, forcedly fed again to the electrolyte injection opening.

At the beginning of the polishing process, the elastic grindstones 37 and 38 are pressed against the internal surfaces of the free rings 25 and 26, however the free rings 25 and 26 will not be polished because they are rotating in synchronization with the rotation of the elastic grindstones 37 and 38. Here, by disposing the free rings 25 and 26 in two layers with approximately the same length as the elastic grindstones 37 and 38, inertia weight of each becomes small, which results in better response to the rotation of the elastic grindstones 37 and 38.

As the tool electrode 5 rises and the elastic grindstone 37 comes into the cylindrical portion of the long sized cylindrical workpiece W, the elastic grindstone 37 is pressed against its internal surface and polishing is performed based on the following principle. That is, while the electrode 35 is rapidly rotating, a thin passivation coating is generated on the

internal surface of the cylindrical portion via the exposed surface 35a for passivation coating generation before the elastic grindstone 37 begins polishing. Then the elastic grindstone 37 abrades the internal surface of the cylindrical portion, results in removing the passivation coating which lacks viscosity and exposing the metallic base. Immediately after that, electrolytic current concentrates on the height of the metallic base via the exposed surface 35b for intensive elution and performs selective electrolysis. Following the above, the tool electrode 5 gradually rises and the electrolytic integrated polishing is performed on the internal surface of the cylindrical portion until the elastic grindstones 37 and 38 are withdrawn from the cylindrical portion of the long sized cylindrical workpiece W, smoothing the internal surface.

At the initial stage of the polishing process, the free rings 25 and 26 prevent the end surface of the cylindrical portion of the long sized cylindrical workpiece W from being polished into a bell-mouth shape. That is, with regard to the elastic grindstone 37 for example, on its way entering the cylindrical portion, a portion of the elastic grindstone 37 is pressed against the internal surface of the cylindrical portion while the rest of the portions thereof are pressed against the free ring 25. However, because the bores of the cylindrical portion and the free ring 25 are the same, the pressed surface of the elastic grindstone 37 being pressed does not tilt, therefore the end surface of the

cylindrical portion will not be polished into a bell-mouth shape.

When the elastic grindstones 37 or 38 are being withdrawn from the cylindrical portion of the long sized cylindrical workpiece W at the final stage of the polishing process, the free ring 24 prevent the end surface of the cylindrical portion from being polished into a bell-mouth shape.

While the polishing process is being performed, the plastic tube 6 is pressurized and pressed against the internal surfaces of the cylindrical portion of the long sized cylindrical workpiece W, the free rings 23 and 24, and the restricting sleeve 17, respectively preventing minute deflections of the external tube 3 caused by rapid rotation of the rotation axis 4 and the tool electrode 5, which eventually prevents deflection of the tool electrode 5 in the cylindrical portion. By disposing the restricting sleeve 17 with a constant length successively above the free ring mechanism 16, the plastic tube 6 can provide a contacting internal surface until the elastic grindstones 37 and 38 are completely withdrawn from the cylindrical portion of the long sized cylindrical workpiece W and stopped rotating, which can prevent deflection of the external tube 3.

Here, metallic tubes or shapes made from steel, stainless steel, aluminum, aluminum alloy or the like may be exemplified, although not limited to them, for the long sized cylindrical workpiece to which the method according to the present invention

is applied. Besides, the length of the cylindrical portion is ten times as large as the diameter, or more. The long sized cylindrical workpiece is finished to have a roundness of the internal surface of the cylindrical portion thereof equal to or smaller than 10μm and a surface roughness Rmax equal to or smaller than 1μm, by the electrolytic integrated polishing.

(Example 1)

A 600 mm long aluminum extrusion hollow shape, having a cross section shown in Fig. 5 was disposed in a vertical type electrolytic integrated polishing apparatus shown in Fig. 1 for polishing its central cylindrical portion (32 mm of finishing bore). Polishing was performed with the tool electrode having two-layered electrodes and elastic grindstones for coarse polishing and finishing, and under a condition that the electrolyte was sodium nitrate aqueous solution (20%), applied voltage was 8V, rotation speed of the tool electrode was 2.5 m, rising speed was 1m per minute.

As a result, roundness of the shape at the central cylindrical portion, which was 450μm before polishing, became 9.2μm after polishing, surface roughness (Rmax) along axial direction, which was 0.8μm before polishing, became 0.5μm after polishing, and surface roughness (Rmax) along circular direction, which was 1.98μm before polishing, became 0.3μm after polishing, all of which showed a largely improved precision.

(Example 2)

A 600 mm long stainless steel cold-finished tube was disposed in a vertical type electrolytic integrated polishing apparatus shown in Fig. 1 for polishing its internal surface (32 mm of finishing bore). Polishing was performed with the tool electrode having two-layered electrodes and elastic grindstones for coarse polishing and finishing, and under a condition that the electrolyte was sodium nitrate aqueous solution (20%), applied voltage was 8V, rotation speed of the tool electrode was 3.0 m, rising speed was 0.4m per minute.

As a result, surface roughness (Rmax) of the base tube, which was 10μm before polishing, became after finishing, 0.2μm with a grain size #1500 and 0.08μm with a grain size #6000, all of which provided an excellent mirror finishing.

Applicability to Industry

According to the present invention, polishing of the internal surface of the cylindrical portion of a long sized cylindrical workpiece with a high precision in terms of roundness and surface roughness becomes possible, without machining. Therefore, for example, a process, wherein a workpiece still in the form of a long sized material is polished and afterwards cut into pieces with a length of a fluid pressure cylinder, can be performed, improving the efficiency of the high-precision polishing and the productivity. Additionally, the present invention can be applied to high-precision polishing of the

internal surfaces of the cylindrical portions of metallic shapes having a variety of external shapes.

Claims

1. An electrolytic integrated polishing method for polishing an internal surface of a cylindrical portion of a long sized cylindrical workpiece by integrating elution by electrolyte and abrasion by a grindstone attached to a tool electrode inserted into the cylindrical portion, said method comprising the steps of disposing the long sized cylindrical workpiece so that an axial center of the cylindrical portion is aligned with the vertical direction, inserting the tool electrode attached to the tip of a rotation axis supported downward similarly along the vertical direction into the cylindrical portion, and rotating as well as relatively moving the tool electrode along the vertical direction.

2. The polishing method for the internal surface of the cylindrical portion of a long sized cylindrical workpiece according to claim 1, wherein the long sized cylindrical workpiece is an aluminum extrusion hollow shape.

3. The polishing method for the internal surface of the cylindrical portion of a long sized cylindrical workpiece according to claim 1, wherein the long sized cylindrical workpiece is a stainless steel cold-finished tube.

4. An electrolytic integrated polishing apparatus for polishing

an internal surface of a cylindrical portion of a long sized cylindrical workpiece by integrating elution by electrolyte and abrasion by a grindstone attached to a tool electrode inserted into the cylindrical portion, said apparatus comprising a work supporting unit for disposing the long sized cylindrical workpiece so that the axial center of its cylindrical portion is aligned with the vertical direction, a rotation axis supported downward along the vertical direction and inserted into the cylindrical portion of said long sized cylindrical workpiece, a tool electrode attached to the tip of the rotation axis, and a transportation unit for moving said rotation axis and/or the work supporting unit along the axial direction.

5. An electrolytic integrated polishing apparatus for polishing an internal surface of a cylindrical portion of a long sized cylindrical workpiece by integrating elution by electrolyte and abrasion by a grindstone attached to a tool electrode inserted into the cylindrical portion, said apparatus comprising a work supporting unit for disposing the long sized cylindrical workpiece so that the axial center of its cylindrical portion is aligned with the vertical direction, a rotation axis inserted into the cylindrical portion of said long sized cylindrical workpiece, a coaxial external tube supported downward along the vertical direction to free-rotatably support said rotation axis and inserted together with said rotation axis into the cylindrical portion of said long sized cylindrical workpiece, a tool electrode

attached to the tip of said rotation axis, and a transportation unit for moving said rotation axis and/or the work supporting unit along the axial direction.

6. The electrolytic integrated polishing apparatus for polishing the internal surface of the cylindrical portion of a long sized cylindrical workpiece according to claim 5, wherein a plastic tube, inside of which can be pressurized, is spirally wound around the peripheral of said external tube.

7. The electrolytic integrated polishing apparatus for polishing the internal surface of the cylindrical portion of a long sized cylindrical workpiece according to any one of claims 4 to 6, wherein a free ring, having approximately the same bore as a finished bore of said cylindrical portion, is free-rotatably disposed to the upper and the lower positions of the cylindrical portion of the long sized cylindrical workpiece.

8. The electrolytic integrated polishing apparatus for polishing the internal surface of the cylindrical portion of a long sized cylindrical workpiece according to claim 6, wherein a free ring, having approximately the same bore as the finished bore of said cylindrical portion, is free-rotatably disposed to the upper and the lower positions of the cylindrical portion of the long sized cylindrical workpiece, and a restricting sleeve with a predetermined length, having approximately the same bore as the

bore of said free ring, is disposed further above the free ring disposed at the upper side.

9. The electrolytic integrated polishing apparatus for polishing the internal surface of the cylindrical portion of a long sized cylindrical workpiece according to any one of claims 4 to 8, wherein a hollow portion is provided inside the tool electrode, and a plastic tube, inside of which can be pressurized, is provided in said hollow portion.

10. A long sized cylindrical workpiece, with the length of a cylindrical portion thereof being ten times as large as a diameter thereof, or more, finished by the electrolytic integrated polishing to have a roundness of an internal surface of the cylindrical portion equal to or smaller than 10μm and a surface roughness Rmax equal to or smaller than 1μm.

ABSTRACT

There is provided an electrolytic integrated polishing apparatus which enables high precision polishing of the internal surface of a long sized cylindrical workpiece such as a metallic tube. The apparatus includes a work supporting unit 13 for disposing the cylindrical workpiece W, so that the axial center of the cylindrical portion is aligned with the vertical direction, a rotation axis 4 supported downward along the vertical direction and free-rotatably supported in an external tube 3 which is freely movable along the vertical direction, a tool electrode 5 including a grindstone directed to radial directions, attached to the tip of the rotation axis 4, and a plastic tube 6 wound around the external surface of the external tube 3 for pressurization. While the polishing process is performed, the plastic tube 6, inside of which is pressurized, expands in the gap between the external tube 3 and the internal surface of the cylindrical portion of the shape W, or the gap between the external tube 3 and the internal surface of the free ring, preventing deflections of the external tube 3 caused by rapid rotation of the rotation axis 4 and the tool electrode 5, which eventually prevents deflection of the tool electrode 5 in the cylindrical portion.

Fig.1

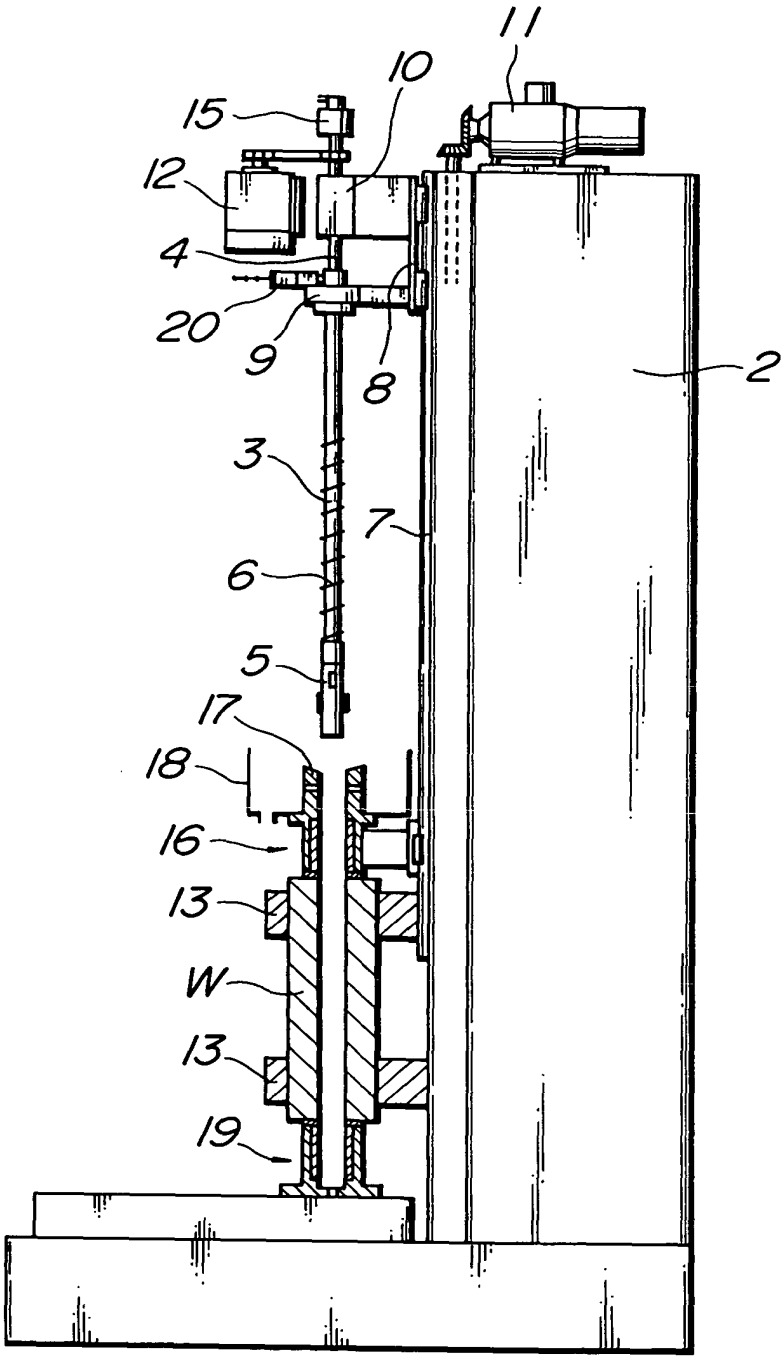


Fig.2

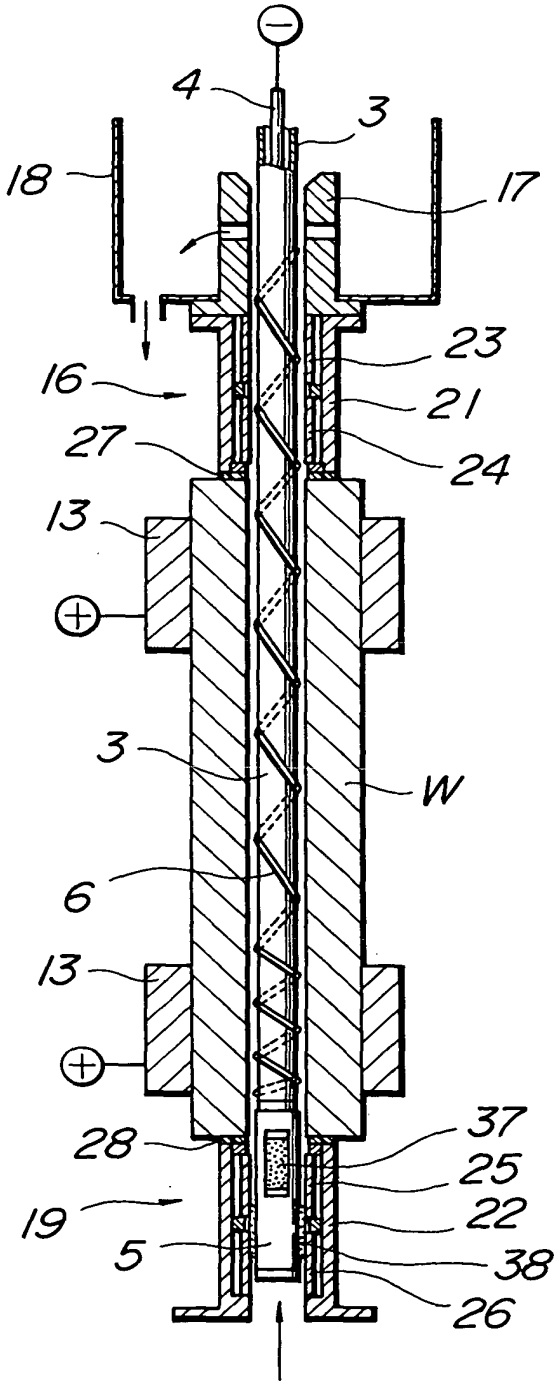


Fig.3

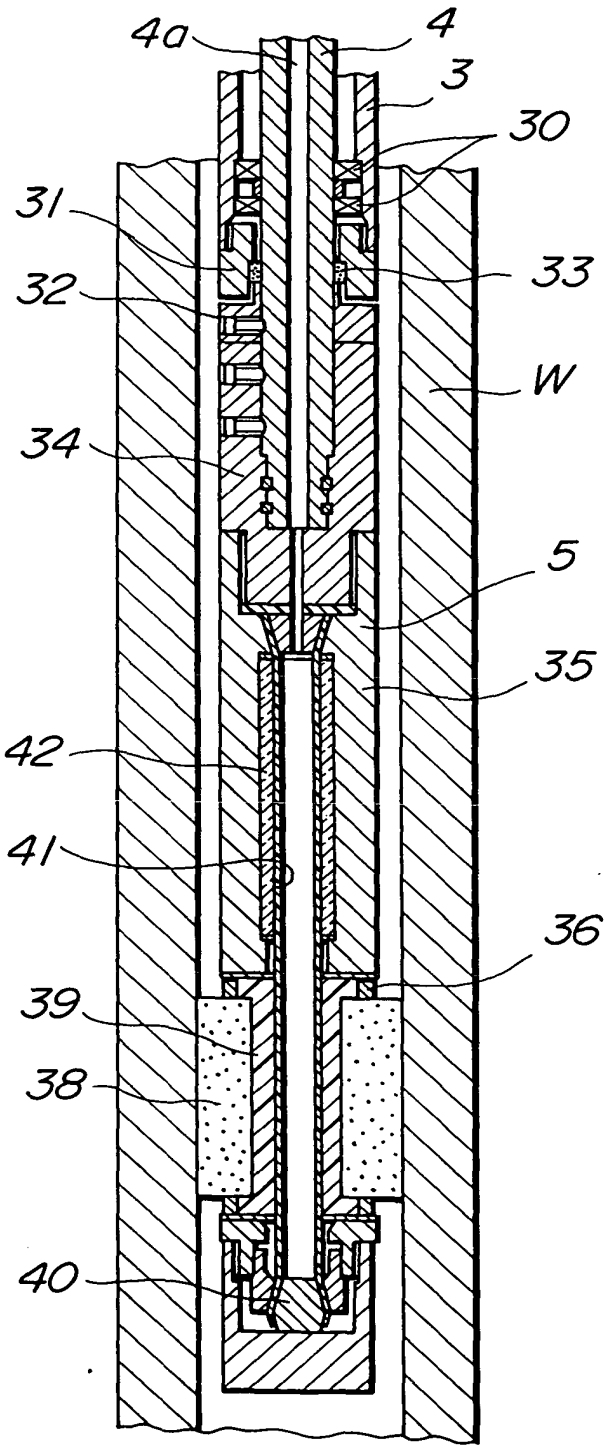


Fig.4

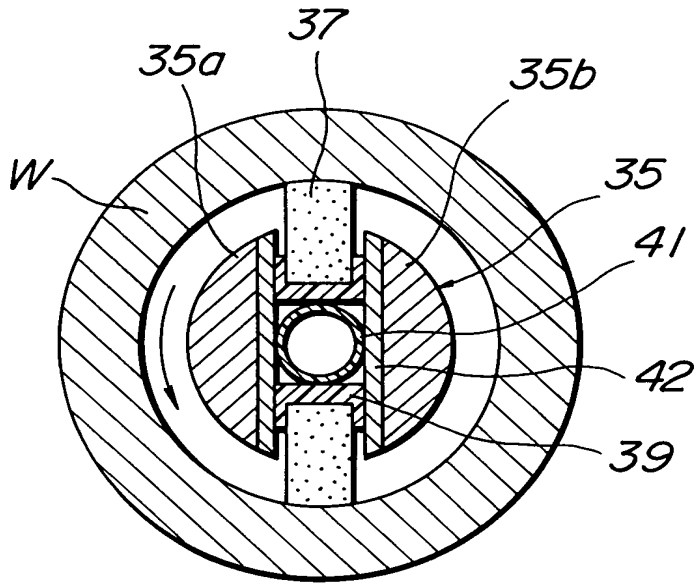


Fig.5